Simulations for Multiple-grid Inertial Electrostatic Confinement

Drew Chap, Raymond Sedwick
University of Maryland
3710 Martin Hall, College Park, MD 20740
240-687-2518
amchap@umd.edu, sedwick@umd.edu

Inertial electrostatic confinement (IEC) is a means of confining and maintaining a non-neutral, non-Maxwellian plasma with an electric field, with the goal of creating fusion for neutron production or energy production. The primary application for the IEC concept in development at the University of Maryland is for the propulsion of spacecraft by either providing power for electric propulsion systems or by using the kinetic energy of the fusion products directly for thrust. Multiple-grid IEC is a method devised to increase the confinement time of ions with the additional positively charged electrostatic grids to focus ion beam paths and limit thermalization. Research at the University of Maryland is also investigating the use of radially magnetized grids to confine electrons to neutralize the IEC core and beam paths.

A hybrid particle-in-cell (PIC) simulation is in development that treats ions using standard PIC methods and models electrons as a fluid. The results from this method on a test problem are shown in Figure 1. In this 2D test problem, electrons are created in the center of the domain and confined by the magnetic fields created by six current-carrying wires. The governing equations for the electron fluid are the continuity equation, momentum equation in the cold plasma limit, and Poisson's equation. For verification, the fluid solution is compared to a particle-in-cell simulation. Accuracy of the fluid approximation is evaluated through this comparison.

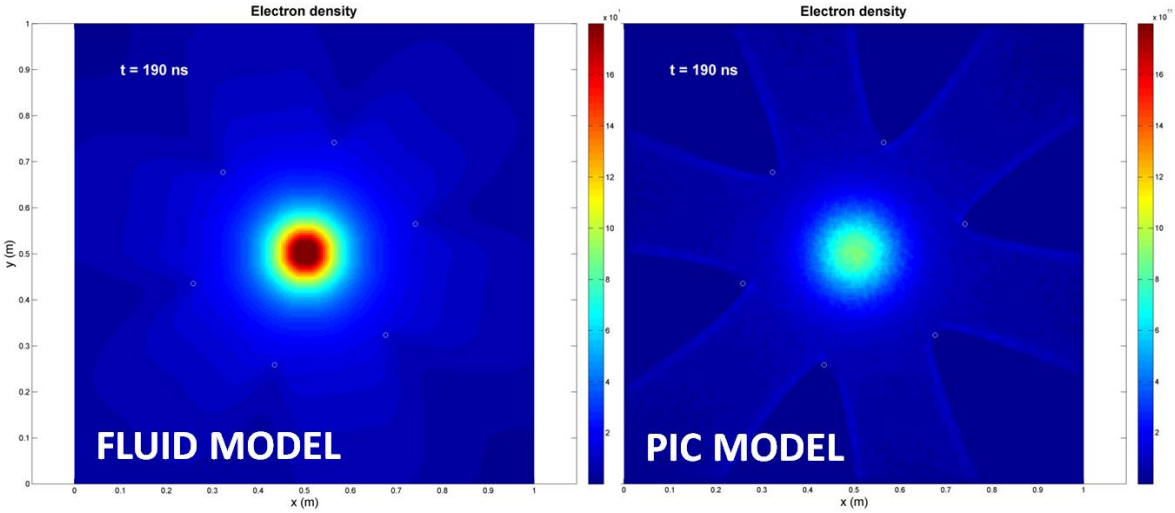

Figure 1. Electron fluid simulation compared with an electron particle-in-cell simulation with the same input parameters.

A second model, a particle-particle discrete-event simulation, has been developed to overcome the computational limitations inherent in field-solving over a large 3D simulation domain and to provide another view of the physics of the multi-grid IEC. This method calculates inter-particle forces directly, so that the electric field over the domain does not have to be calculated at each time-step, providing fast calculation for low density, large domain simulation.